US005759073A

United States Patent [19]

Sumino et al.

[11] Patent Number: 5,759,073

[45] Date of Patent: Jun. 2, 1998

[54] DUAL PROPELLER SYSTEM FOR MARINE DRIVE

[75] Inventors: **Yoshitsugu Sumino; Ryoji Nakahama**, both of Hamamatsu, Japan

[73] Assignee: **Sanshin Kogyo Kabushiki Kaisha**, Shizuoka, Japan

[21] Appl. No.: **707,523**

[22] Filed: **Sep. 4, 1996**

[30] **Foreign Application Priority Data**

Sep. 4, 1995 [JP] Japan 7-226651

[51] **Int. Cl.**^{6} **B63H 5/10**

[52] **U.S. Cl.** **440/81**; 440/66

[58] **Field of Search** .... 440/80, 81, 89; 416/90 R, 90 A, 93 R, 93 A, 128, 236 A

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,099,229	11/1937	Possenheim	416/236 A
3,012,709	12/1961	Schnell	416/236 A
3,434,447	3/1969	Christensen et al. .	
4,545,771	10/1985	Iio .	
4,793,773	12/1988	Kinouchi et al.	416/93 A
4,802,872	2/1989	Stanton	416/93 A
5,529,520	6/1996	Iwashita et al. .	

FOREIGN PATENT DOCUMENTS

2319832	10/1973	Germany	416/93 A

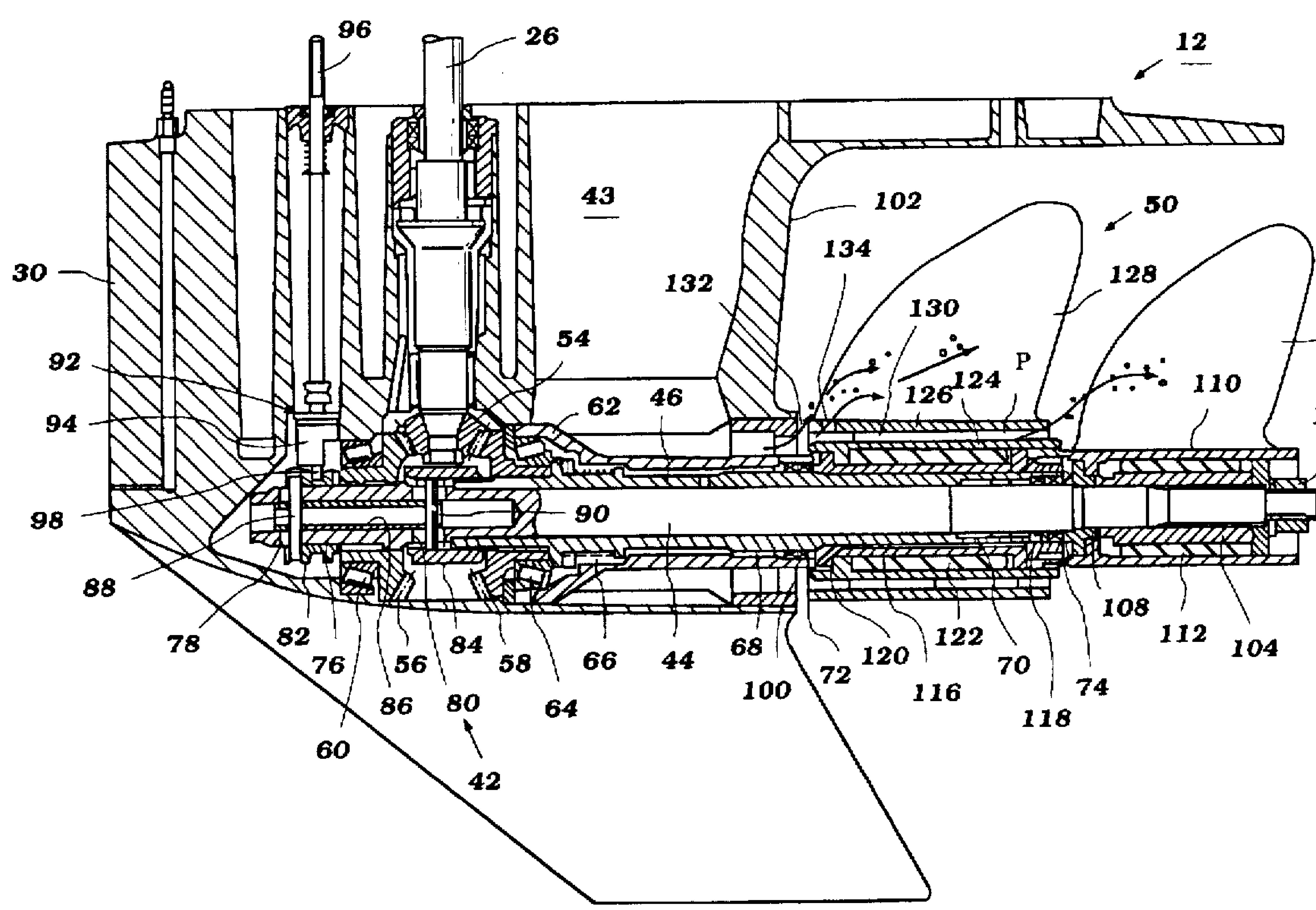
Primary Examiner—Jesus D. Sotelo

Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear, LLP

[57] **ABSTRACT**

A propulsion system for a marine drive, which includes a pair of counter-rotating propellers, provides improved acceleration from idle or low speeds. Engine exhaust from an engine which powers the marine drive is conveyed to the water about each of the propellers. The exhaust gases aerate the water about each propeller to reduce drag resistance on each propeller. Several embodiments of the propulsion system are disclosed which convey the exhaust gases to both propellers for this purpose.

32 Claims, 7 Drawing Sheets



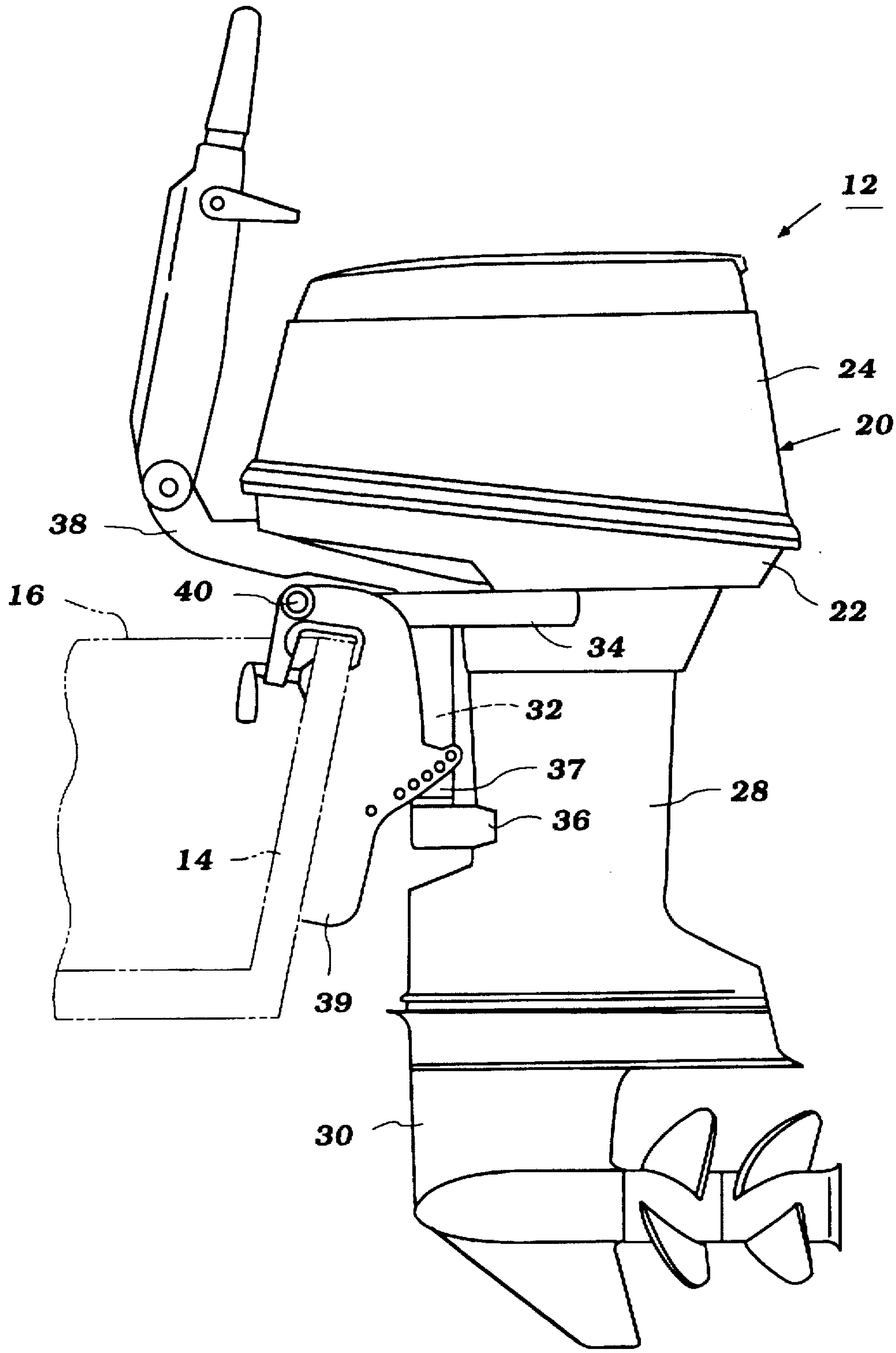


Figure 1

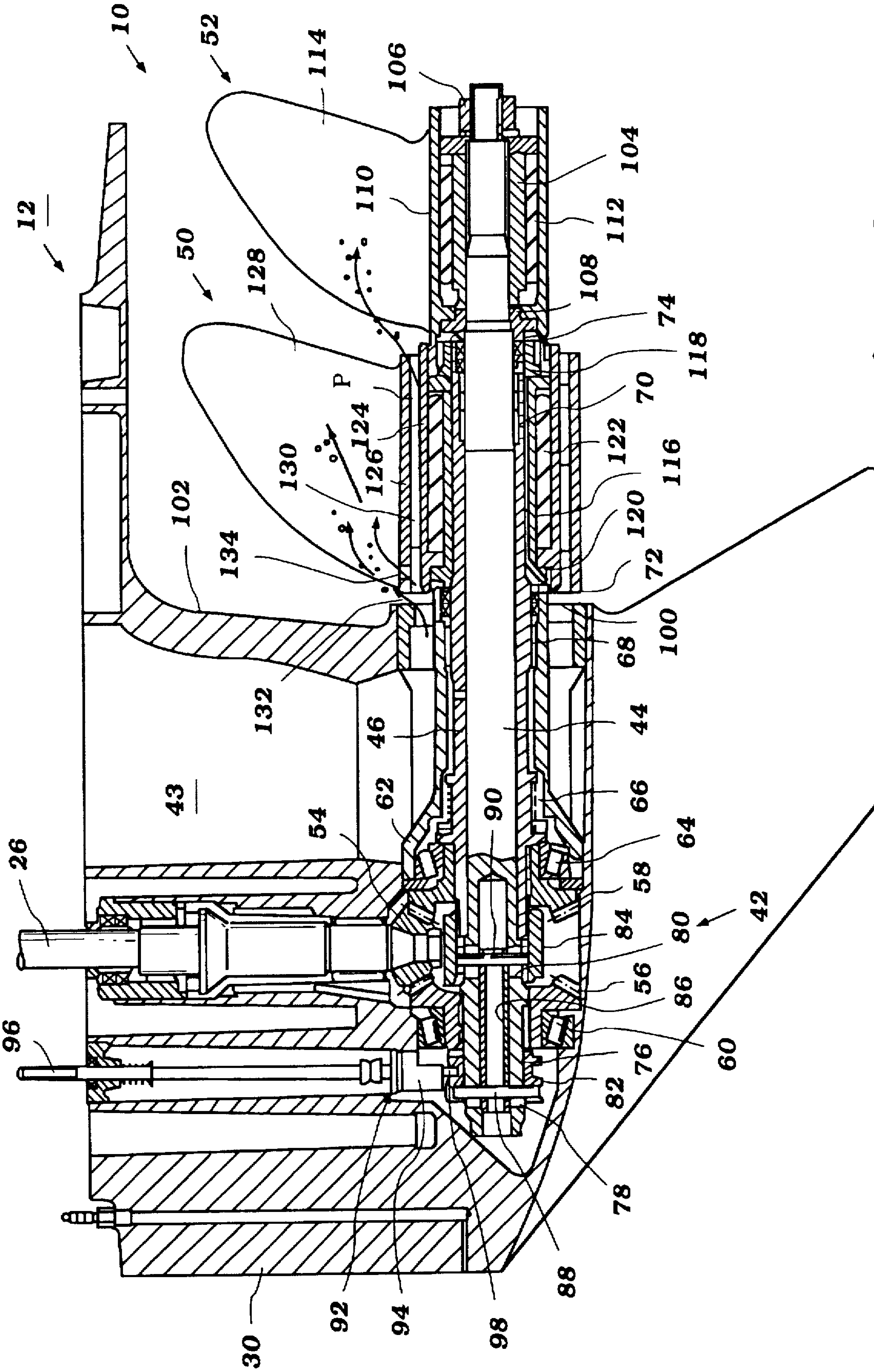

10
12
52
50
114
106
104
110
112
108
128
74
118
P
70
124
126
122
130
116
120
102
134
72
100
68
132
46
44
43
62
66
54
64
90
58
26
84
80
42
56
86
96
60
76
82
78
30
92
94
98
88

Figure 2

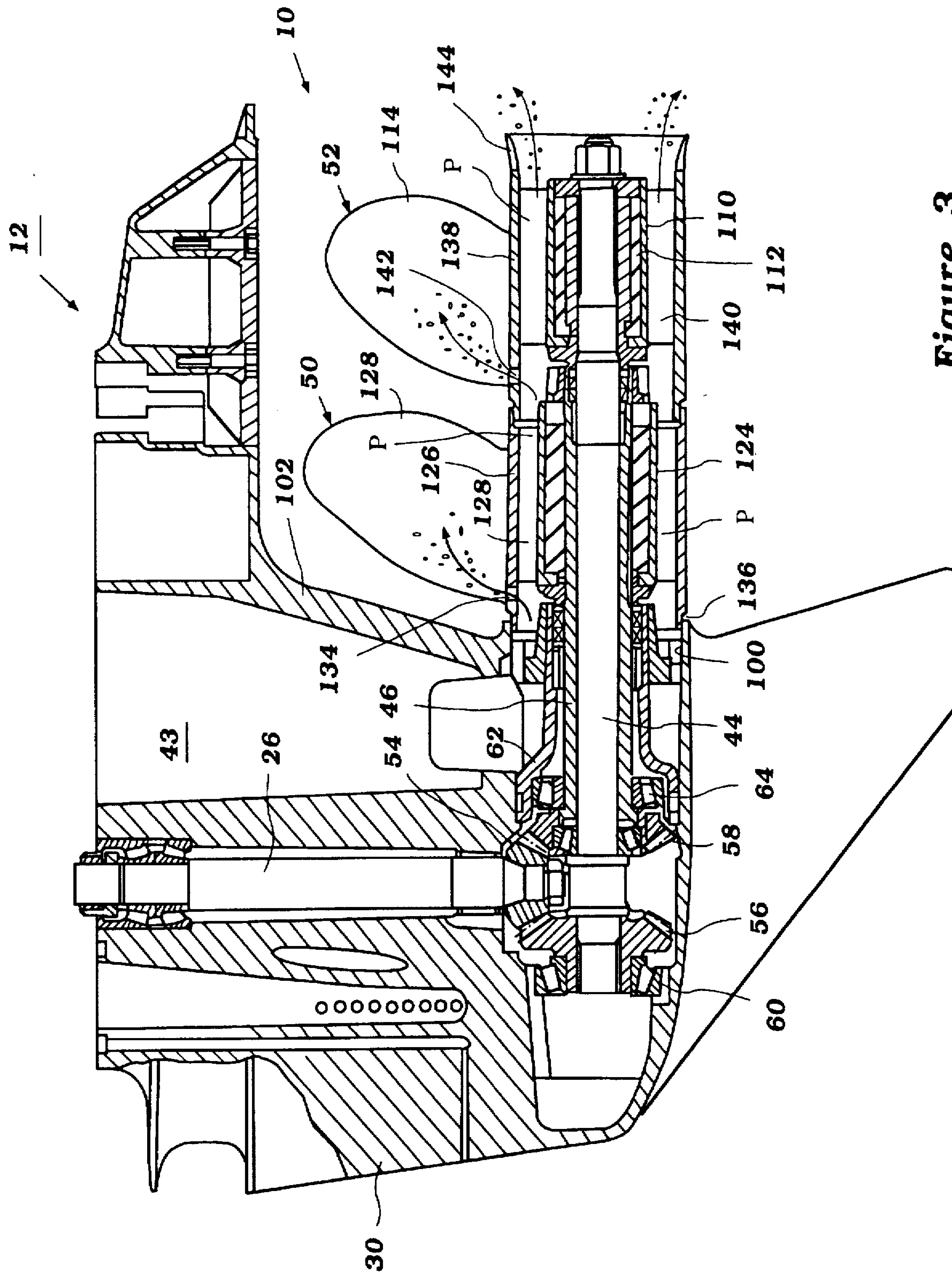

10
12
144
114
52
P
110
112
138
142
140
50
128
P
126
124
102
128
P
136
134
100
46
44
43
62
54
26
64
58
56
60
30

Figure 3

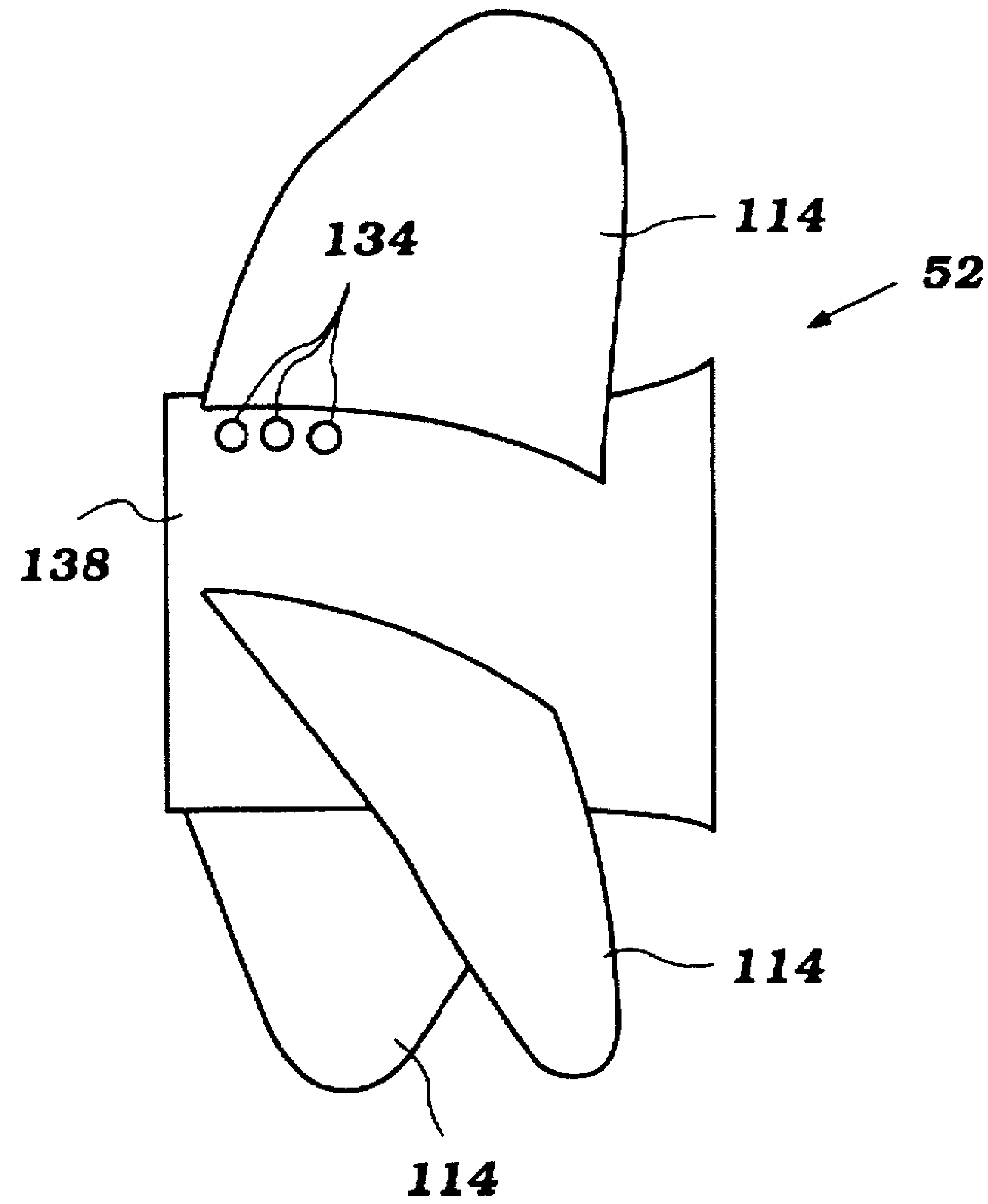


Figure 4

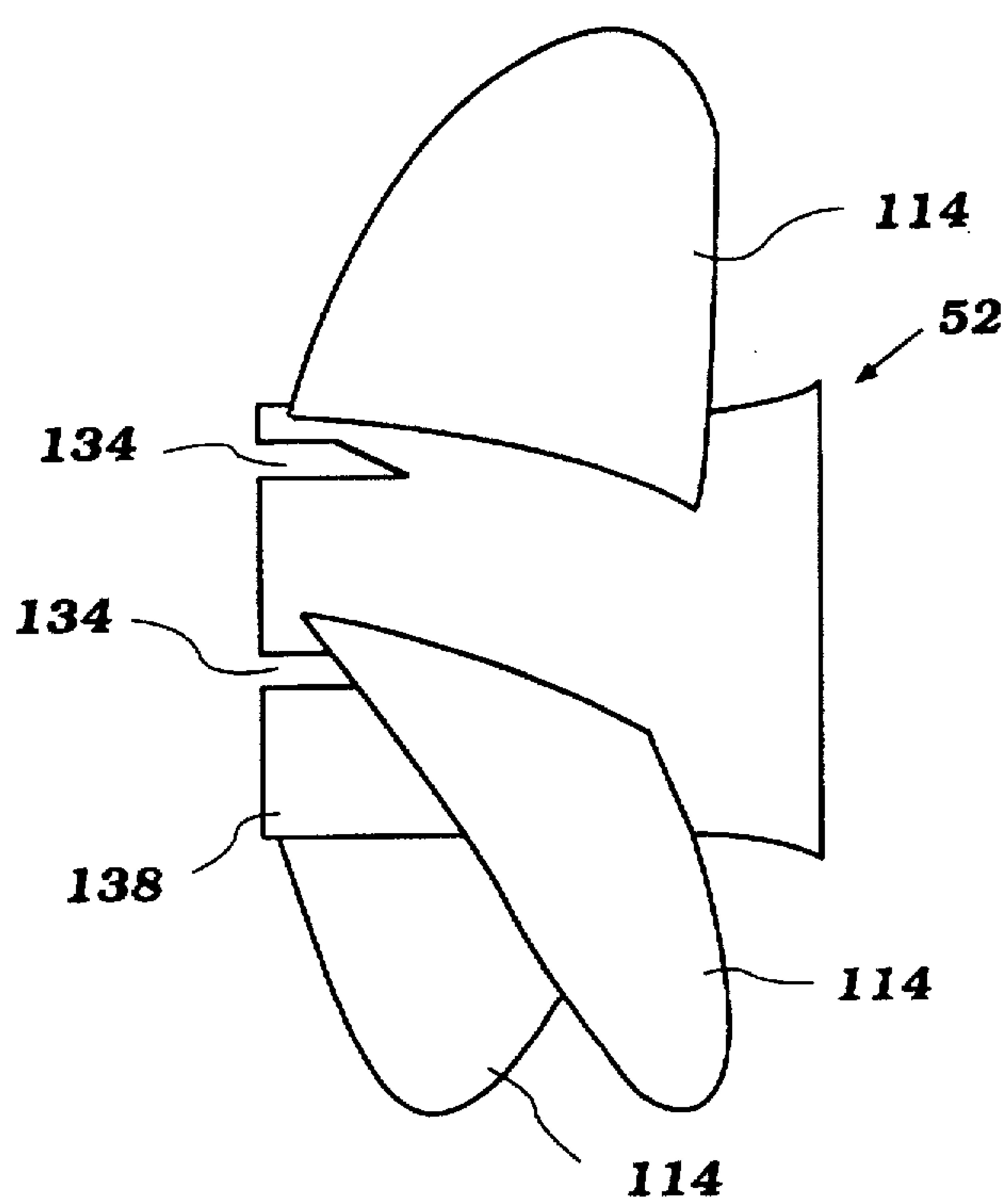


Figure 5

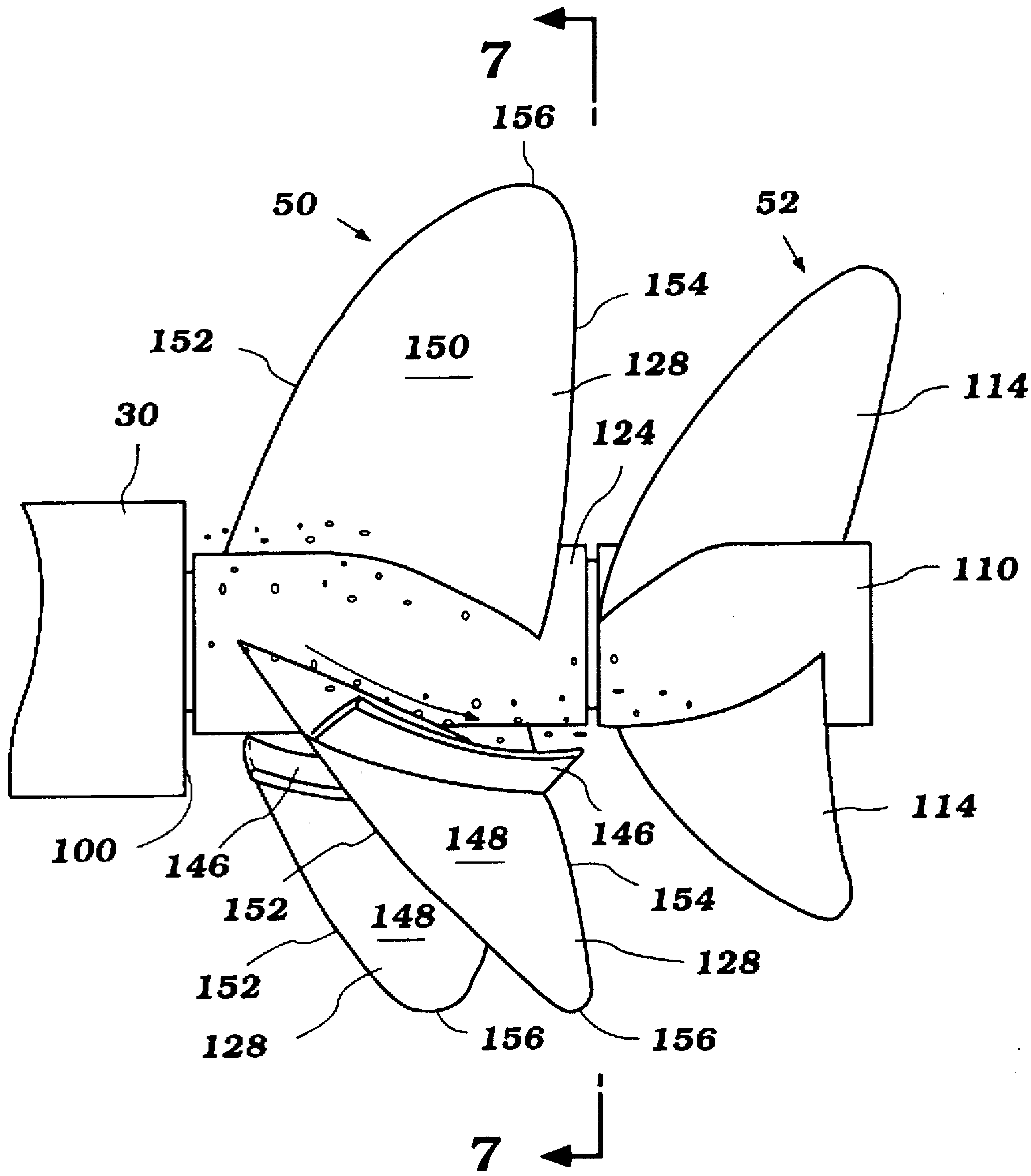

7
156
50
52
154
152
150
128
114
30
124
110
100
146
148
146
114
152
154
148
128
152
128
156
156
7

Figure 6

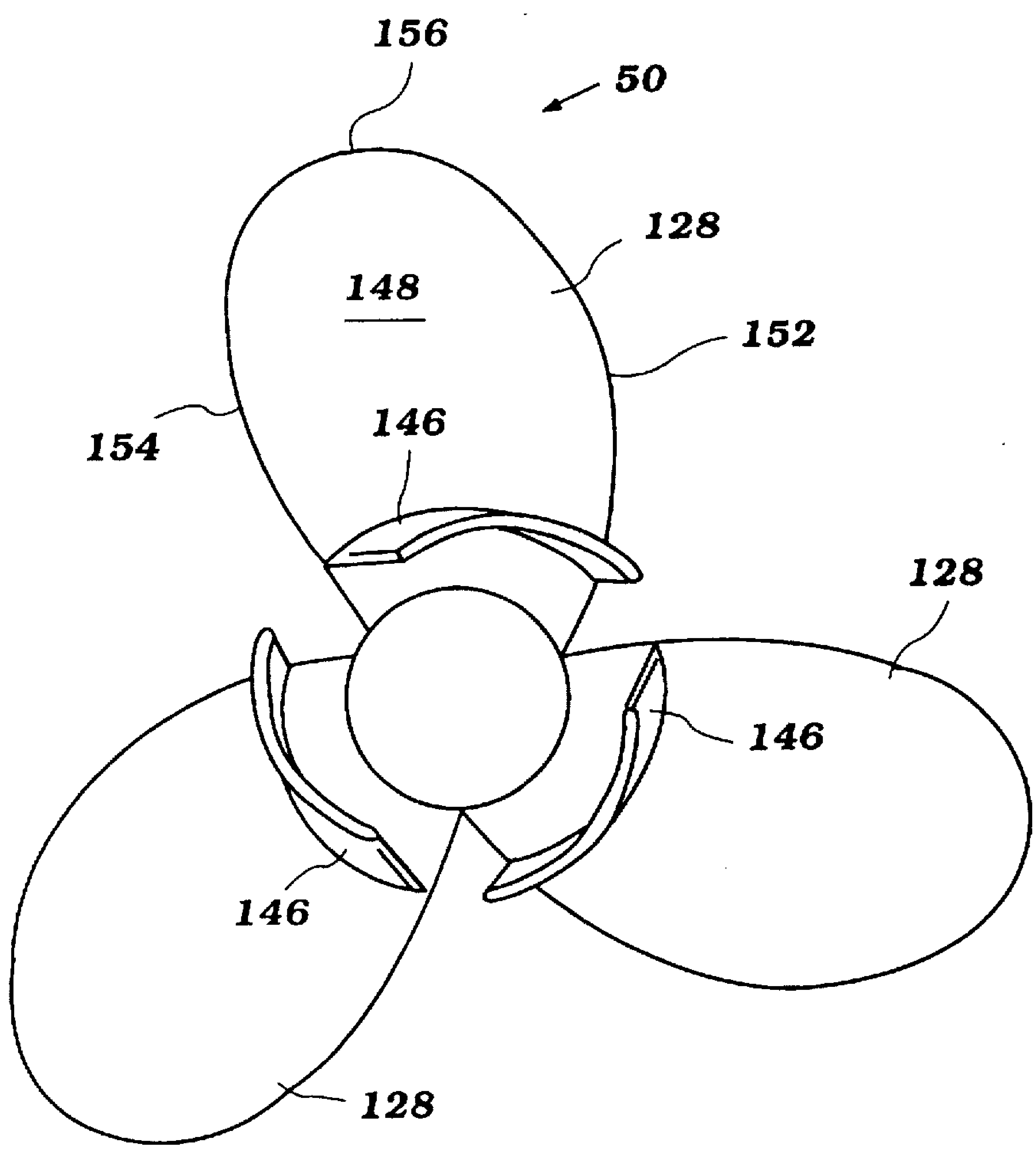


Figure 7

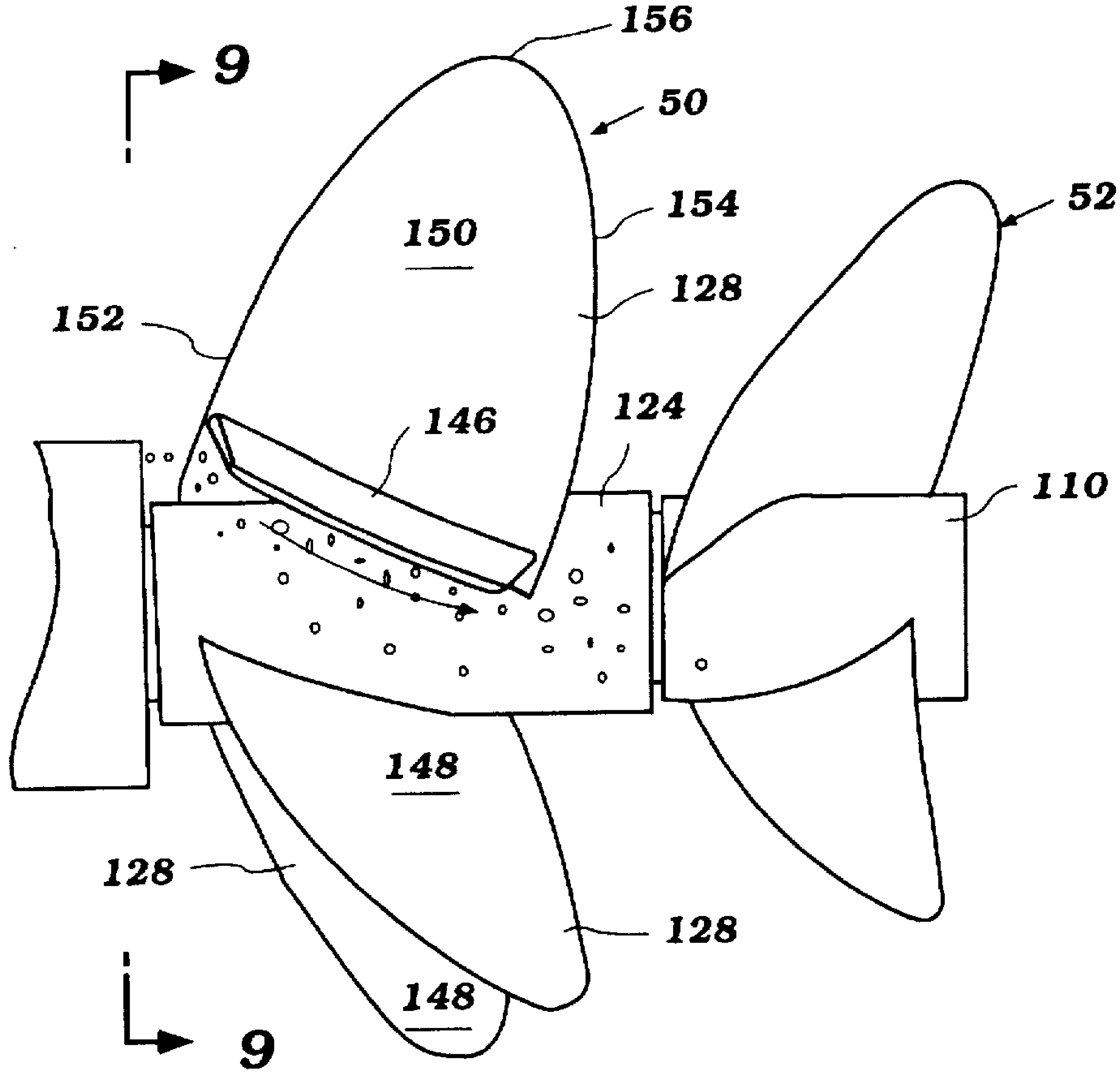


Figure 8

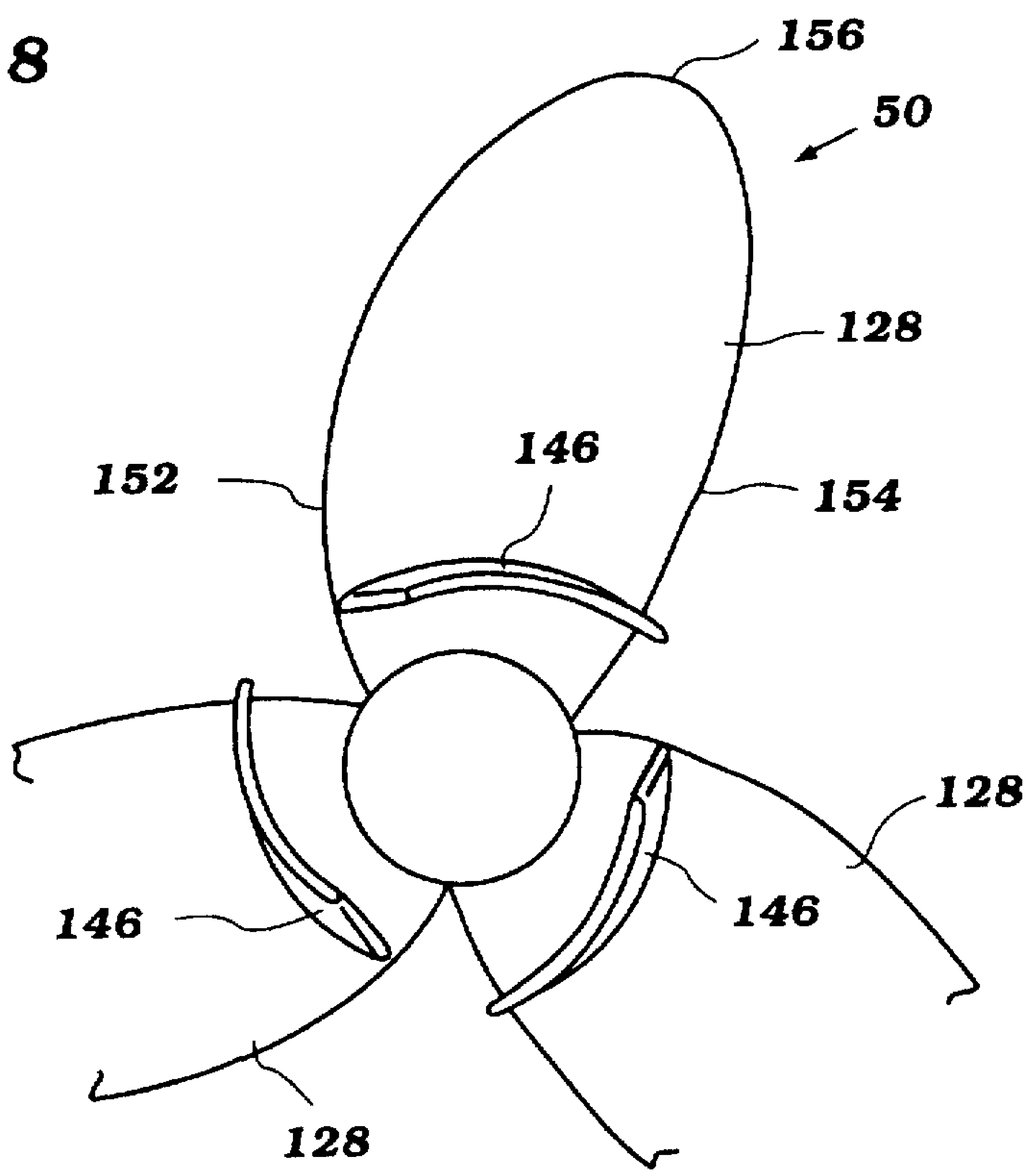


Figure 9

DUAL PROPELLER SYSTEM FOR MARINE DRIVE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a marine drive. In particular, the present invention relates to an improves exhaustion system used with a dual counter-rotating propeller system of a marine drive.

2. Description of Related Art

Many marine propulsion systems now employ a counter-rotating propeller device. Front and rear propellers of the system, which are of opposite hand and which rotate in opposite directions about a common drive axis, together produce a forward driving thrust. This dual propeller arrangement provides improved propulsion efficiency and enhances the handling characteristics of the watercraft.

Counter-rotating propeller devices, however, place a large load on the engine associated with the marine propulsion system. The drag of the two propellers significantly reduces the ability of the engine to quickly accelerate the propellers. Propeller blade acceleration consequently suffers. The propellers take longer to accelerate to a desired rotational speed. As a result, the marine propulsion system takes longer to get the associated watercraft up on plane (i.e., planing over the surface of the body of water in which the watercraft is operated).

In order to quicken acceleration, some marine drives discharge at least a portion of exhaust gas discharge upstream of the propulsion system when operating at idle or at low speeds. U.S. Pat. No. 5,529,520, issued to Sanshin Industries, the assignee hereof, discloses an example of this type of marine drive. The exhaust gases discharged in the vicinity of the front propeller aerate the water so as to reduce water resistance on the front propeller. The propellers consequently accelerates more quickly.

SUMMARY OF THE INVENTION

The present invention includes the recognition that acceleration of the propulsion system can be improved by discharging engine exhaust in the vicinity of each of the propellers, rather than at a point upstream of the propulsion system. One aspect of the present invention thus involves a marine drive in which engine exhaust is conveyed to the vicinity of each of the propellers of a dual counter-rotating propulsion system of the marine drive. At idle or at low speeds, the exhaust gases aerate the water around both of the propellers. The propellers consequently accelerate quickly as less drag resistance occurs in the aerated water about both of the propellers.

For this purpose, a marine drive which includes a propulsion device is provided. The propulsion device comprises front and rear propellers which are intended to rotate in opposite directions about a common rotational axis. A lower housing supports the propulsion device. An exhaust system cooperates with the propulsion system to discharges exhaust gases through the lower housing, as well as to a first location in the vicinity of the front propeller and to a second location in the vicinity of the rear propeller. The dual-location exhaustion aerates the water about both the front and rear propellers for improved acceleration.

Another aspect of the present invention involves a marine drive including an internal combustion engine which drives a propulsion device for a watercraft. The propulsion device comprises a first propeller and a second propeller. The

propellers are intended to rotate in opposite directions relative to each other with the second propeller being positioned behind the first propeller. Exhaust discharge means is provided for conveying exhaust gases from the engine to a first location near the first propeller and to a second location near the second propeller.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will now be described with reference to the drawings of preferred embodiments which are intended to illustrate and not to limit the invention, and in which:

FIG. 1 is a side elevational view of an outboard motor of a type which can incorporate the present propulsion system;

FIG. 2 is a partial-sectional, side view of a lower unit of an outboard motor which includes a propulsion system configured in accordance with a preferred embodiment of the present invention;

FIG. 3 is a partial-sectional, side view of a lower unit of an outboard motor which includes a propulsion system configured in accordance with another preferred embodiment of the present invention;

FIG. 4 is a side elevational view of another embodiment of a propeller which can be used with the propulsion system of **FIG. 3**;

FIG. 5 is a side elevational view of an additional embodiment of a propeller which can be used with the propulsion system of **FIG. 3**;

FIG. 6 is a side elevational view of a propulsion system configured in accordance with an additional preferred embodiment of the present invention;

FIG. 7 is a rear view of a front propeller of the propulsion system of **FIG. 6** as viewed in the direction of line **7—7**, with the associated propulsion shafts and the internal structure of the propeller's hub omitted for simplicity;

FIG. 8 is a side elevational view of a propulsion system configured in accordance with another preferred embodiment of the present invention; and

FIG. 9 is a front view of a front propeller of the propulsion system of **FIG. 8** as viewed in the direction of line **9—9**, with the associated propulsion shafts and the internal structure of the propeller's hub omitted for simplicity.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present propulsion system **10** provides for quicker acceleration than conventional drives by using engine exhaust to aerate the water about the blades of both of its propellers when accelerating from low speeds. The invention thus has applicability with a variety of types of marine drives, such as, for example, with outboard drives, with inboard/outboard drives, and with inboard drives. In order to illustrate the invention, the present propulsion system is described in connection with an outboard motor; however, this environment of use is merely exemplary.

Before describing the present propulsion system, the general components of a conventional outboard motor **12**, as mounted on a transom **14** of a watercraft **16**, are first described in order to aid the reader's understanding of the illustrated embodiment. The details of the present propulsion system **10** then follow.

FIG. 1 illustrates a conventional outboard motor **12**. The outboard motor **12** has a power head **18** which includes an engine (not shown). A conventional protective cowling **20**

surrounds the engine. The cowling **20** desirably includes a lower tray **22** and a top cowling member **24**. These components **22**, **24** of the protective cowling **20** together define an engine compartment which houses the engine.

The engine is mounted conventionally with its output shaft (i.e., crankshaft) rotating about a generally vertical axis. The crankshaft (not shown) drives a drive shaft **26** (see FIG. 2), as known in the art. The drive shaft **26** depends from the power head **18** of the marine drive **10**.

A drive shaft housing **28** extends downward from the lower tray **22** and terminates in a lower unit **30**. The drive shaft **26** extends through and is journaled within the drive shaft housing **28**.

A steering shaft **32** is affixed to the drive shaft housing **28** by upper and lower brackets **34**, **36**. The brackets **34**, **36** support the steering shaft **32** within a swivel bracket **37** for steering movement. Steering movement occurs about a generally vertical steering axis which extends through a shaft of the steering shaft assembly **32**, as known in the art. A steering arm **38** which is connected to an upper end of the steering shaft can extend in a forward direction for manual steering of the marine drive **10**, as known in the art.

The steering shaft assembly **32** also is pivotably connected to a clamping bracket **39** by a pin **40**. The clamping bracket **34**, in turn, is configured to attached to the transom **14** of the watercraft **16**. This conventional coupling permits the marine drive **10** to be pivoted relative to the pin **40** to permit adjustment of the trim position of the marine motor **10** and for tilt-up of the marine motor **10**.

Although not illustrated, it is understood that a conventional hydraulic tilt and trim cylinder assembly, as well as a conventional hydraulic steering cylinder assembly can be used as well with the present marine drive **10**. The construction of the steering and trim mechanism is considered to be conventional and, for that reason, further description is not believed necessary for appreciation and understanding of the present invention.

FIG. 2 illustrates a preferred embodiment of the propulsion system **10** together with an exemplary transmission **42** and exhaust discharge passage **43** within the lower unit **30**. As illustrated in this figure, the drive shaft **26** extends from the drive shaft housing **28** into the lower unit **30** where a transmission **42** selectively couples the drive shaft **26** to an inner propulsion shaft **44** and to an outer propulsion shaft **46**. The transmission **42** advantageously is a forward/neutral/reverse-type transmission. In this manner, the drive shaft **26** drives the inner and outer propulsion shafts **44**, **46** (which rotate in a first direction and in a second counter direction, respectively) in any of these operational states, as described below in detail.

The propulsion shafts **44**, **46** drive the propulsion device **10**. As mentioned above, the propulsion device **10** is a counter-rotating propeller device that includes a front propeller **50** designed to spin in one direction and to assert a forward thrust, and a rear propeller **52** designed to spin in the opposite direction and to assert a forward thrust. The counter-rotational propulsion device **10** will be explained in detail below.

The drive shaft **26** carries a drive gear **54** at its lower end, which is disposed within the lower unit **30** and which forms a portion of the transmission **42**. The drive gear **54** preferably is a bevel type gear.

The transmission **42** also includes a pair of counter-rotating driven gears **56**, **58** that are in mesh engagement with the drive gear **54**. The pair of driven gears **56**, **58** preferably are positioned on diametrically opposite sides of the drive gear **54**, and are suitably journaled within the lower unit **30**, as described below. Each driven gear **56**, **58** is positioned at about a 90° shaft angle with the drive gear **54**. That is, the propulsion shafts **44**, **46** and the drive shaft **26**, desirably intersect at about a 90° shaft angle; however, it is contemplated that the drive shaft **26** and the propulsion shafts **44**, **46** can intersect at almost any angle.

In the illustrated embodiment, the pair of driven gears **56**, **58** are a front bevel gear and an opposing rear bevel gear. The front gear **56** includes a hub which is journaled within the lower unit **30** by a front thrust bearing. The front thrust bearing **60** rotatably supports the front gear **56** in mesh engagement with the drive gear **54**. The hub has a central bore through which the inner propulsion shaft **44** passes when assembled. The inner propulsion shaft **44** is suitably journaled within the central bore of the front gear hub.

The front gear **56** also includes a series of teeth on an annular front-facing engagement surface, and includes a series of teeth on an annular rear-facing engagement surface. The teeth on each surface positively engage a portion of a clutch of the transmission **42**, as described below.

The rear gear **58** also includes a hub which is suitably journaled within a bearing carrier **62** by a rear thrust bearing **64**. The rear thrust bearing **64** rotatably supports the rear gear **58** in mesh engagement with the pinion **54**.

The hub of the rear gear **58** has a central bore through which the inner propulsion shaft **44** and the outer propulsion shaft **46** pass. The rear gear **58** also includes an annular front engagement surface which carries a series of teeth for positive engagement with a clutch of the transmission **42**, as described below.

The inner propulsion shaft **44** and the hollow outer propulsion shaft **46** are disposed within the lower unit **30**. The bearing casing **62** rotatably supports the outer propulsion shaft **46**. A front needle bearing assembly **66** journals a front end of the outer propulsion shaft **46** within the bearing casing **66**. A needle bearing assembly **68** supports the outer propulsion shaft **46** within the bearing casing **62** at an opposite end of the bearing casing **62** from the front bearing assembly **66**.

As seen in FIG. 2, the inner propulsion shaft **44**, as noted above, extends through front gear hub and the rear gear hub, and is suitably journaled therein. On the rear side of the rear gear **58**, the inner shaft **44** extends through the outer shaft **46** and is suitably journaled therein by at least one needle bearing assembly **70** which supports the inner shaft **44** at the rear end of the outer shaft **46**.

A first pair of seals **72** (e.g., oil seals) are interposed between the bearing casing **62** and outer propulsion shaft **46** at the rear end of the bearing casing **62**. Likewise, a second pair of seals **74** (e.g., oil seals) are interposed between the inner shaft **44** and the outer shaft **46** at the rear end of the outer shaft **46**. Lubricant within a lubricant sump flows through the gaps between the bearing casing **62** and the outer shaft **46**, and between the outer shaft **46** and the inner shaft **44** to lubricate the bearings **66**, **68**, **70** that support the inner propulsion shaft **44** and the outer propulsion shaft **46**. The seals **72**, **74**, located at the rear ends of the bearing casing **62** and of the outer shaft **46**, substantially prevent lubricant flow beyond these points.

The front end of the inner propulsion shaft **44** includes a longitudinal bore **76**. The bore **76** stems from the front end of the inner shaft **44** to a bottom surface which is positioned on the rear side of the axis of the drive shaft **26**. A front aperture **78** extends through the inner shaft **44**, transverse to the axis of the longitudinal bore, at a position forward of the front bevel gear **56**. The inner shaft **44** also includes a rear aperture **80** that extends transverse to the axis of the longitudinal bore **76** and is generally symmetrically positioned between the front bevel gear **56** and the rear bevel gear **58**.

As best seen in FIG. **3**, the transmission **42** also includes a front dog clutch **82** and a rear dog clutch **84** coupled to a plunger **86**. The front dog clutch **82** selectively couples the inner propulsion shaft **44** to the front gear **58**. The rear dog clutch **84** selectively couples the outer propulsion shaft **46** to either the front gear **56** or to the rear gear **58**. FIG. **2** illustrates the front dog clutch **82** and the rear dog clutch **84** set in a neutral position (i.e., in a position in which the clutches **82**, **84** do not engage either the front gear **56** or the rear gear **58**).

The plunger **86** has a generally cylindrical rod shape and slides within the longitudinal bore of the inner shaft **76** to actuate the clutches **82**, **84**. The plunger **76** may be solid; however, it is preferred that the plunger **86** be hollow.

, The plunger **86** includes a front hole that is positioned generally transverse to the longitudinal axis of the plunger **86**, and a rear hole that is likewise positioned generally transverse to the longitudinal axis of the plunger **86**. Each hole desirably is located symmetrically in relation to the corresponding apertures of the inner propulsion shaft **44**.

The front dog clutch **82** has a generally cylindrical shape that includes an axial bore. The bore extends through an annular front end and a flat annular rear end of the clutch **82**. The bore is sized to receive the inner propulsion shaft **44**. Internal splines are formed on the wall of the axial bore. The internal splines mate with external spines formed on the front end of the inner propulsion shaft **44**. The resulting spline connection establishes a driving connection between the front clutch **82** to the inner propulsion shaft **44**, while permits the clutch **82** to slide along the front end of shaft **44**.

The annular rear end surface of the clutch **82** lies generally transverse to the longitudinal axis of the inner propulsion shaft **44**. The rear surface of the front dog clutch **82** also is substantially coextensive in the area with the annular front surface of the front gear **56**. Teeth extend from the clutch rear surface in the longitudinal direction and desirably corresponds with the teeth on the front surface of the front driven gear **56**, both in size (i.e., axial length), in number, and in configuration.

A pair of annular grooves circumscribe the exterior of the front clutch **82**. A front groove is sized to receive a retaining spring, as described below. The rear groove is sized to cooperate with an actuator mechanism, which will be described below.

The front clutch **82** also includes a traverse hole that extends through the clutch at the location of the front annular groove. The hole is sized to receive a pin **88** which, when passed through the front aperture **78** of the inner propulsion shaft **44** and through the front hole of the plunger **86**, interconnects the plunger **86** and the front clutch **82** with the front clutch **82** positioned on the inner propulsion shaft **44**. The pin **88** may be held in place by a press-fit connection between the pin **88** and the front hole, or by a conventional coil spring (not shown) which is contained within the front annular groove about the exterior of the front clutch **82**.

The rear clutch **84** is disposed between the two counter-rotating driven gears **56**, **58**. The rear clutch **84** has a tubular shape that includes an axial bore which extends between an annular front end and an annular rear end. The bore is sized to receive a portion of the outer propulsion shaft **46**, which is positioned about the inner propulsion shaft **44**.

The annular end surfaces of the rear clutch **84** are substantially coextensive in size with the annular engagement surfaces of the front and rear gears **56**, **58**, respectively. Teeth extend from the front end of the rear clutch **84** and desirably correspond to the respective teeth of the front gear **56** in size (e.g., axial length), in number, and in configuration. Teeth likewise extend from the rear end surface of the rear clutch **58** and desirably correspond to the respective teeth of the rear gear **58** in size (e.g., axial length), in number, and in configuration.

A spline connection couples the rear clutch **84** to the outer propulsion shaft **46**. The clutch **84** thus drives the outer propulsion shaft **46** through the spline connection, yet the clutch **84** can slide along the front end of the shaft **46** between the front and rear gears **56**, **58**.

The rear clutch **84** also includes a counterbore. The counterbore is sized to receive a coupling pin **90** which extends through the rear aperture **80** of the inner propulsion shaft **44** and through the rear slot of the plunger **86**. The pin **90** has a diameter smaller than the length of the aperture **80**.

The ends of the pin **90** desirably are captured by an annular bushing which is interposed between a pair of roller bearings. The assembly of the bushings and bearings is captured between a pair of washers and locked within the counterbore of the rear dog clutch **84** by a retainer ring (not shown). The roller bearings journal the assembly of the bushing and the pin **90** within the counterbore to allow the bushing and the pin **90** to rotate in an opposite direction from the rear clutch **84**. The pin **90**, being captured within the counterbore of the rear clutch **84**, however, couples the plunger **86** to the rear clutch **84** in order for the plunger **86** to actuate the rear clutch **84**, as described below.

An actuator mechanism **92** moves the plunger **86** of the clutch assembly from a position establishing a forward drive condition, in which the front and rear clutches **82**, **84** engage the front and rear gears **56**, **58**, respectively, through a position of non-engagement (i.e., the neutral position), and to a position establishing a reverse drive condition, in which the rear clutch **84** engages the front gear **56**. The actuator mechanism **92** positively reciprocates the plunger **86** between these positions.

The actuator mechanism **92** includes a cam member **94** that connects the front clutch **82** to a rotatable shift rod **96**. In the illustrated embodiment, the shift rod **96** is journaled for rotation in the lower unit **30** and extends upwardly to a transmission actuator mechanism (not shown) positioned within the outboard motor cowling **20**. The actuator mechanism **92** converts rotational movement of the shift rod **96** into linear movement of the front clutch **82** to move the front clutch **82**, as well as the plunger **84** and the rear clutch **84**, along the axis of the propulsion shaft **44**, **46**.

The cam member **94** is affixed to a lower end of the shift rod **96**. The cam member **94** includes an eccentrically positioned drive pin **98** which extends downwardly from the cam member **94**. The cam member **94** also includes a cylindrical upper portion which is positioned to rotate about the axis of the shift rod **96** and is journaled within the lower unit **30**. The drive pin **98** extends into the rear annular groove of the front clutch **82** and is sized to slide within the groove.

The drive pin **98** of the cam member **94** moves both axially and transversely with rotation of the cam member **94** because of the eccentric position of the drive pin **98** relative to the rotational axis of the shift rod **96**. The pin **98** transfers the linear or axial component of the eccentric motion of the cam member **94** to the front clutch **82**. The transverse component of the cam member's motion, however, is not transferred to the front clutch **82**. This motion is lost as the pin 98 slides within the rear groove of the front clutch 82. The actuator mechanism 92 configured accordingly positively moves the front clutch 82 along the axis of the inner propulsion shaft 44 with rotational movement of the cam member 94 operated by the shift rod 96. The coupling between the actuator mechanism 92 and the front clutch 82, however, allows the front clutch 82 to rotate with the inner propulsion shaft 44 relative to the drive pin 98.

The pin 88, which connects the front clutch 82 to the plunger 86, causes the plunger 86 to rotate with the front clutch 82 and the inner propulsion shaft 44. The coupling also conveys the axial movement of the clutch 82 driven by the actuator mechanism 92 to the plunger 86. The plunger 86 consequently moves the rear clutch 84.

As noted above, the bearing carrier 62 supports the propulsion shafts 44, 46 on a side of the transmission 42 opposite of the shift actuator mechanism 92. In the illustrated embodiment, the bearing carrier 62 lies within the lower unit 30, and more specifically within the exhaust discharge conduit 43 of the lower unit 30. The exhaust discharge conduit 43 forms a part of an exhaust system. For this purpose, the exhaust discharge conduit 43 communicates with an expansion chamber (not shown) formed in the drive shaft housing 28 (FIG. 1). The exhaust system communicates with the engine of the outboard motor 12 and conveys exhaust gases to the expansion chamber for silencing, as known in the art. From the expansion chamber, the exhaust gases are discharged through the exhaust discharge conduit 43.

The exhaust conduit 43 in the lower unit 30 extends from an upper end of the lower unit 30 to an exhaust outlet 100 formed on a rear wall 102 of the lower unit 30. The exhaust outlet 100 desirably has a circular shape and generally is concentrically positioned about a common drive axis of the shafts 44, 46.

As understood from FIG. 2, the propeller shafts 44, 46, when coupled to the drive shaft 26 by the transmission 42, drive the propulsion device 10. The propulsion device 10 of FIG. 2 will now be described in detail.

As seen in FIG. 2, the inner shaft 44 extends beyond the rear end of the outer shaft 46. The rear end of the inner shaft 44 carries an engagement sleeve 104 of the rear propeller 52. The engagement sleeve 104 has a spline connection with the rear end of the inner shaft 44. The sleeve 104 is fixed to the inner shaft rear end between a retaining washer secured by a nut 106 threaded on the rear end of the shaft 44 and a rear thrust washer 108 that engages the inner shaft 44 proximate to the rear end of the outer shaft 46.

The inner shaft 44 also carries a rear propeller hub 110. An elastic bushing 112 is interposed between the engagement sleeve 104 and the propeller hub 110 and is compressed therebetween. The bushing 112 is secured to the engagement sleeve 104 by a heat process known in the art. The frictional engagement between the hub 110, the elastic bushing 112, and the engagement sleeve 104 is sufficient to transmit rotational forces from the sleeve 104, driven by the inner propulsion shaft 44, to propeller blades 114 attached to the propeller hub 110.

The outer shaft 46 carries the front propeller 50 in a similar fashion. The rear end portion of the outer shaft 46 carries a second engagement sleeve 116 in driving engagement thereabout by a spline connection. The second engagement sleeve 116 is secured onto the outer shaft 46 between a retaining ring 118 and a front thrust washer 120.

A second annular elastic bushing 122 surrounds the second engagement sleeve 116. The bushing 122 is secured to the sleeve 116 by a heat process known in the art.

An inner propeller hub 124 of the front propeller 50 surrounds the elastic bushing 122, which is held under pressure between the hub 124 and the sleeve 116 in frictional engagement. The frictional engagement between the propeller hub 124 and the bushing 122 is sufficient to transmit a rotational force from the sleeve 116 to propeller hub 124.

The front propeller 50 also includes an outer propeller hub 126 to which at least one propeller blade 128 is integrally formed. A plurality of radial ribs 130 extend between the inner hub 124 and the outer hub 126 to support the outer hub 126 about the inner hub 124 and to form passages P through the propeller 52. At least a portion of the engine exhaust is discharged through these passages P, as described below.

As seen in FIG. 3, the front and rear propellers 50, 52 desirably include a plurality of propeller blades, although a singe blade can be used. In the illustrated embodiment, the propellers each include four blades which are integrally formed with the respective outer hub.

The propulsion system 10 also includes an exhaust conveyer which communicates with the exhaust discharge conduit 43 and discharges exhaust gases at two locations: a first location in the vicinity of the front propeller 50 and a second location in the vicinity of the second propeller 52. For this purpose, in the illustrated embodiment, the exhaust conveyer includes a first exhaust egress located in front of the front propeller 50 and a second exhaust egress located in front of the rear propeller 52.

In the illustrated embodiment, the first exhaust egress includes a gap 132 formed between the rear wall 102 of the lower unit 30 and the front propeller 50. The exhaust discharge conduit 43 communicates with the exhaust outlet opening 100 such that a portion of the exhaust gases flowing though the opening 100 flow through the gap 132 when the propellers 50, 52 are idle or running at low speeds.

The first exhaust egress also can include a plurality of opening 134 positioned behind the gap 132. Each opening 134 desirably lies near the front of one of the propeller blades 128 on a blade-face side of the propeller blade 50.

The second exhaust egress in the illustrated embodiment is formed at the end of the front propeller 50. As seen in FIG. 2, an inner diameter of the front propeller outer hub 126 is larger than an outer diameter of the hub 110 of the rear propeller 52. The exhaust passage P through the front propeller 50 terminates at a rear end of the propeller 50 and discharges exhaust gases in front of the rear propeller blades 114. The exhaust system therefore discharges exhaust gases in the vicinity of the juxtaposed ends of the front and rear propellers 50, 52, between the blades 128, 114 of the propellers 50, 52.

In operation, the exhaust system conveys exhaust gases from the engine to the exhaust discharge conduit 43 in the lower unit 30. At least a portion of the exhaust gases flow through the exhaust outlet 100 into the passages P within the front propeller 50 and discharge between the propeller blades 128, 114. At low propeller speeds, at least a portion of the exhaust gases also flow through the gap 132 and the openings 134 in the vicinity of the front end of the front propeller blades 128. The exhaust gases discharged near each of the propellers 50, 52 aerate the water around the propeller blades 128, 114 of the front and rear propellers 50, 52. As schematically illustrated in FIG. 2, the action of the blades 128, 114 of the propellers 50, 52 drives the exhaust gases outwardly away from the respective hub 126, 110 of the propeller 50, 52. The exhaust gases flow over the blade back of the propeller blades 128, 114 and become entrained in the water stream through the propellers 50, 52.

Aeration or cavitation produced by the entrained exhaust gases within the water decreases the viscosity of the water around the blades **128**, **114** to reduce drag resistance on the blades **128**, **114**. This permits the propellers **50**, **52** to accelerate more rapidly.

Less propeller resistance in turn reduces the load applied by the propellers **50**, **52** on the engine, and more power is available to drive both propellers **50**, **52**. The outboard motor **12** consequently accelerates quicker.

Water speed over the propellers **50**, **52**, as well as exhaust speed through the propellers **50**, **52**, increase with rising engine and propeller speeds. The exhaust gases consequently tend to flow through the exhaust passages P within the front propeller hub **126**, rather than through the gap **132** and the openings **134**. The exhaust gases also tend to flow over the rear propeller hub **110**. The speed of the exhaust gases, as well as the speed of the water flow over the propellers, carries the gasses through the rear propeller **52** in the vicinity of the bases of the propeller blades **114**. As a result, the discharged exhaust gases have less effect on cavitation and causes no significant loss of propulsion efficiency when traveling at high speeds.

The following additional embodiments illustrate further variants of an exhaust conveyer used with a dual, counter-rotating propeller system. As understood from the above description, the exhaust conveyer assists the delivery of exhaust gases to locations near propellers to create some cavitation effect around the blades of the front and rear propellers. Because many of the components of the following marine drives are similar to those described above, the above description of similar components should be understood to apply as well to the components of the following embodiment, unless otherwise stated. For this purpose, like reference numerals have been used to indicate like parts between the embodiments.

With reference to FIG. **3**, the first exhaust egress is formed by openings **134** that extend through the outer hub **126** of the front propeller in a transverse direction relative to the rotational axis of the propeller **50**. At least one opening **134** lies near the front of one of the propeller blades **128** on the blade-face side of the propeller blade **128**.

As seen in FIG. **3**, the outer hub **126** of the front propeller **128** includes an annular step **136** formed at its front end. The step **136** permits the front end of the propeller **50** to fit within the exhaust opening **100** with a portion of the rear wall **102** of the lower unit **30** overlapping in the axial direction the front portion of the propeller hub **126**. In this position, the exhaust passages P communicate with the exhaust discharge conduit **43** through the outlet opening **100**.

In the illustrated embodiment, the rear propeller **52** also includes an outer propeller hub **138** to which at least one propeller blade **114** is integrally formed. A plurality of radial ribs **140** extend between the inner hub **110** and the outer hub **138** to support the outer hub **138** about the inner hub **110** and to form passages P through the propeller **52**. At least a portion of the engine exhaust is discharged through these passages P, as described below.

The second exhaust egress includes a plurality of openings **142** that extend through the outer hub **138** of the rear propeller **52** in a transverse direction relative to the rotational axis of the propeller **52**. At least one opening **142** lies near the front of one of the propeller blades **114** on the blade-face side of the propeller blade **114**.

At idle and low engine and propeller speeds, some exhaust gas flow through the openings **134**, **142**, which are positioned near the blades **128**, **114** of the front and rear propellers **50**, **52**. The exhaust gases aerate the water around the propellers **50**, **52**, in the manner described above, to quicken acceleration. At high speeds, however, the speed of the exhaust and the low pressure formed at the rear of the rear propeller **52** tends to cause the exhaust gases to flow through a diffuser ring **144** positioned at the rear end of the rear propeller **52**.

FIGS. **4** and **5** illustrate variations of the propeller which can be used in the propulsion system **10** described above in connection with FIG. **3**. Although these figures illustrate the propeller as configured as the rear propeller **52**, it is understood that the exhaust egress described in connection with the propeller can be used equally well with the front propeller **52** of the propulsion system **10**.

The propeller **52** of FIG. **4** includes a plurality of rows of openings **142**. Each row of openings **134** lie near the front of one of the propeller blades **114** and on the blade-face side of the propeller blade **114**.

FIG. **5** illustrates the exhaust egress openings **142** of the propeller **52** as slots.

The slots **142** extend into the outer hub **138** of the rear propeller **52** from the propeller's front end. Each slot **142** projects to a point behind the front of a corresponding propeller blade **114** and lies to the side of the blade-face of the propeller blade **114**.

FIG. **6** illustrates a propulsion system **10** configured in accordance with another preferred embodiment of the present invention. In this embodiment, the propeller blades **128**, **114** of the front and rear propellers **50**, **52** are directly mounted to the corresponding inner hub **124**, **110**. The propellers **50**, **52** thus do not include exhaust passages P through their hubs.

Engine exhaust is discharged through the outlet opening **100** on the rear wall **102** of the lower unit **30** in front of the front propeller **50**. The outboard drive includes an exhaust conveyer which conveys at least a portion of the engine exhaust toward the rear propeller **52**, while permitting the remaining portion of the engine exhaust to flow through the blades **128** of the front propeller **50**.

In the illustrated embodiment, the exhaust conveyer includes a plurality of ribs **146**. Each rib **146** is attached to a surface of the propeller and projects from the surface in a direction generally normal to the surface. In the illustrated embodiment, the ribs **146** project from the blade-faces **148** of the propeller blades **128** of the front propeller; however, as seen in FIGS. **8** and **9**, the ribs can project from the blade-backs **150** of the front propeller blades.

As seen in FIGS. **6** and **7**, each rib **146** desirably extends from a leading edge **152** of the propeller blade **128** to a trailing edge **154** of the propeller blade **128**. The ribs also are positioned closer to the base of the propeller blades **128** (i.e., the point wherein the blade **128** attaches to the propeller hub **124**) than to a blade tip **156** of the propeller blade **128**.

In operation, engine exhaust is discharge through the outlet opening **100** in front of the front propeller **50**. At low speeds, the action of the blades **128** of the front propeller **50** drives a portion of the exhaust gases outwardly away from the propeller hub **126**. The exhaust gases flow over the blade backs **150** of the propeller blades **128**, and become entrained in the water stream through the propeller **50**.

The ribs **146** of the blade-faces **148** of the front propeller trap a portion of the exhaust gases exiting the outlet opening **100** and direct these gases toward the rear propeller **52**. In this manner, exhaust gases, which are discharged in front of the front propeller **50**, are conveyed to the rear propeller **52** so as to aerate the water about the rear propeller **52**.

Water and exhaust speeds over the propellers **50**, **52** increase with rising engine and propeller speeds. The exhaust gases consequently tend to flow over the hubs **124**, **110** of the propellers **50**, **52** and have less effect on cavitation. The speed of the exhaust gases, as well as the speed of the water flow over the propellers **50**, **52**, carries the gasses through the propellers **50**, **52** in the vicinity of the bases of the propeller blades **128**, **114**. As a result, the discharged exhaust gases have less effect on cavitation and causes no significant loss of propulsion efficiency when traveling at high speeds.

As common to each of the embodiments described above, the exhaust system cooperates with the propulsion system to convey engine exhaust two separate locations: a first location positioned near the front propeller; and a second location positioned near the second propeller. In some of the embodiments, the exhaust gases are discharged at these locations. In other embodiments, the exhaust gases are conveyed from the first location to the second location. In either case, the effect of aerating the water around both the front and rear propellers meaningfully improves acceleration of the marine drive.

Although this invention has been described in terms of certain preferred embodiments, other embodiments apparent to those of ordinary skill in the art are also within the scope of this invention. Accordingly, the scope of the invention is intended to be defined only by the claims that follow.

What is claimed is:

1. A marine drive for a watercraft comprising a propulsion device including a front propeller and a rear propeller intended to rotate in opposite directions about a common rotational axis, a lower housing which supports the propulsion device, and an exhaust system which cooperates with the propulsion system to discharge exhaust gases through the lower housing and to a first location in the vicinity of the front propeller and to a second location in the vicinity of the rear propeller, the front propeller including a hub and at least one propeller blade attached to the hubs the hub having an internal exhaust passage and an exhaust egress located near the front end of the propeller blade at the first location the exhaust egress including at least one transverse opening extending through the front propeller hub and communicating with the exhaust passage of the front propeller hub.

2. A marine drive as in claim **1**, wherein the exhaust egress additionally comprises a gap formed between the hub of the front propeller and the lower housing.

3. A marine drive as in claim **1**, wherein the front propeller includes a plurality of propeller blades and at least one transverse opening is positioned near a base of each propeller blade.

4. A marine drive as in claim **3**, wherein the transverse opening is a hole.

5. A marine drive as in claim **4**, wherein the exhaust egress comprises at least an additional hole, and the holes are aligned.

6. A marine drive as in claim **3**, wherein the opening is a slot which extends into the hub from a front end of the front propeller.

7. A marine drive as in claim **1**, wherein the rear propeller includes at least one propeller blade attached to a rear propeller hub, and the rear propeller hub includes a second exhaust egress located near the front of the rear propeller blade at the second location.

8. A marine drive as in claim **7**, wherein the second egress is located between the front propeller blade and the rear propeller blade.

9. A marine drive as in claim **8**, wherein the second egress is formed at the end of the exhaust passage through the front propeller.

10. A marine drive as in claim **2**, wherein the rear propeller includes an exhaust passage which is formed through the rear propeller hub and which communicates with the exhaust passage through the hub of the front propeller, and the second egress comprises a transverse opening extending through the hub of the rear propeller.

11. A marine drive as in claim **10**, wherein the rear propeller includes a plurality of propeller blades and at least one transverse opening is positioned near a base of each propeller blade.

12. A marine drive as in claim **11**, wherein the transverse opening is a hole.

13. A marine drive as in claim **12**, wherein the exhaust egress comprises at least one additional hole, and the holes are aligned along a line that extends to the rear of the rear propeller.

14. A marine drive as in claim **11**, wherein the transverse opening is a slot which extends into the propeller hub from a front end of the rear propeller.

15. A marine drive for a watercraft comprising a propulsion device including a front propeller and a rear propeller intended to rotate about a common rotational axis, the front propeller including at least one propeller blade, a lower housing which supports the propulsion device, and an exhaust system which cooperates with the propulsion system to discharges exhaust gases through the lower housing and to a first location in the vicinity of the front propeller and to a second location in the vicinity of the rear propeller, said propulsion system including an exhaust conveyer including a rib that projects from a blade surface of the front propeller blade and extends in a direction from a leading edge of the propeller blade to a trailing edge of the propeller blade, said rib being configured to guide exhaust gases to at least the second location near the rear propeller.

16. A marine drive as in claim **15**, wherein the rib extends from the leading edge to the trailing edge of the propeller blade.

17. A marine drive as in claim **15**, wherein the front propeller includes a plurality of propeller blades, and each blade includes a rib projecting from the blade.

18. A marine drive as in claim **15**, wherein the rib extends from a blade face of the propeller blade.

19. A marine drive as in claim **15**, wherein the rib extends from the blade back.

20. A marine drive as in claim **15**, wherein the rib is located closer to the base of the propeller blade than to tip of the propeller blade.

21. A marine drive comprising an internal combustion engine which drives a propulsion device for a watercraft, the propulsion device including a first propeller and a second propeller which are intended to rotate in opposite directions relative to each other with the second propeller being positioned behind the first propeller, and exhaust discharge means for conveying exhaust gases from the engine to a first location near the first propeller and to a second location near the second propeller to aerate the water of the body of water in which the marine drive is operated about the first and second propellers at least when both propellers are running at low speed to reduce drag resistance on the propellers.

22. The marine drive of claim **21**, wherein each of the first and second propellers includes a plurality of propeller blades.

23. The marine drive of claim **22**, wherein the first location is located in the vicinity of a leading edge of at least one of the blades of the first propeller, and the second location is located in the vicinity of a leading edge of at least one of the blades of the second propeller.

24. The marine drive of claim 23, wherein the first and second propellers are arranged to rotate about a common axis.

25. The marine drive of claim 23, wherein the first location lies in front of at least one blade of the first propeller, and the second location lies in front of at least one blade of the second propeller.

26. The marine drive of claim 23 additionally comprising a lower unit which supports the propulsion system, the lower unit includes an exhaust passage which communicates with the exhaust discharge means.

27. The marine of claim 26, wherein the lower unit houses a transmission coupled to the propulsion system, the transmission being arranged to lie forward at least a portion the exhaust passage of the lower unit.

28. A method of reducing drag on a propulsion device comprising front and rear propellers rotating about a common rotational axis, said method involving the steps of:

rotating the front propeller at a low revolutional speed to produce a forward thrust;

rotating the rear propeller at a low revolutional speed to produce a forward thrust;

discharging a sufficient volume of exhaust gases in the vicinity of the front propeller to aerate the water about the front propeller; and

discharging a sufficient volume of exhaust gases in the vicinity of the rear propeller to aerate the water about the rear propeller.

29. A method as in claim 28, wherein the front and rear propellers are rotated in opposite directions.

30. A method as in claim 28, wherein discharging exhaust gases involve discharging exhaust gases through openings in hubs of the propellers.

31. A method as in claim 28, additionally comprising conveying exhaust gases from a point of discharge near the front propeller to a point of discharge near the rear propeller.

32. A method as in claim 31, wherein conveying involves channeling exhaust gases between a hub of the front propeller and at least one rib formed on at least one blade of the front propeller.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,759,073

DATED : June 2, 1998

INVENTOR(S) : Yoshitsugu Sumino

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Claim 1, column 11, line 36, "the hubs the" should be --the hub, the--.

Signed and Sealed this

Sixteenth Day of February, 1999

Attest:

Attesting Officer

Acting Commissioner of Patents and Trademarks